West Coast Regional Carbon Sequestration Partnership: Phase I Geological Characterization

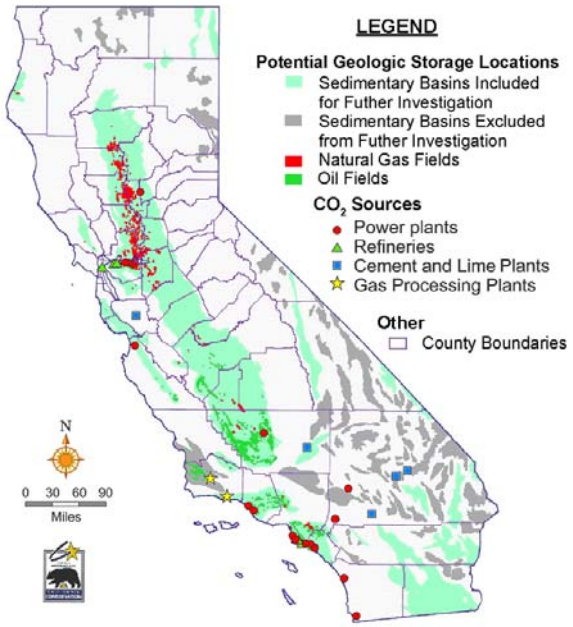
Contract no.	Contractor	Amount* ($)	Contractor Project Manager	Commission Project Manager	Commission Contract Manager
500-03-018	California Department of Conservation, California Geological Survey	130,000	John Clinkenbeard	—	Guido Franco
500-02-004 (MR-021)	California Institute for Energy and Environment (CIEE)*	659,097	Carl Blumstein	Guido Franco	Beth Chambers
500-02-014 (WA-109)	Electric Power Research Institute	651,000	Richard Rhudy	Guido Franco	Beth Chambers
	Total Amount	**1,440,097**			

*CIEE amount is part of a $1,010,097 WESTCARB Phase I agreement

Project Term: 2004–2005

The Issue

Reducing human-made carbon dioxide (CO_2) emissions is a complex challenge requiring multiple solutions; one near-term solution is carbon capture and geologic sequestration (CCS). CCS refers to "capturing" CO_2 before it is released into the atmosphere and storing it out of contact with the atmosphere. It allows society to reduce the carbon intensity of the economy[1] while continuing use of economical fossil fuels, thereby "buying time" to develop and construct affordable non-CO_2-emitting energy systems. Because the magnitude of investment required to replace the current energy infrastructure is immense, it is critical to validate sequestration technologies for scale-up and deployment within the current infrastructure.



Major stationary CO_2 sources and potential geologic CO_2 storage reservoirs in California

Led and co-funded by the California Energy Commission, The West Coast Regional Carbon Sequestration Partnership (WESTCARB) is one of

[1] *Carbon intensity* is the amount of carbon emitted per unit of energy consumed.

seven partnerships that have been established by the U.S. Department of Energy (DOE) to evaluate CCS technologies best suited for different regions of the country. WESTCARB's region includes California, Alaska, Arizona, British Columbia, Nevada, Oregon, and Washington.

Project Description

As part of WESTCARB's Phase I geological characterization, researchers addressed key issues affecting deployment of carbon capture and storage technologies in the WESTCARB region, including:

- Characterizing major point sources of CO_2 in the region.
- Characterizing geologic units (sedimentary basins, oil and gas fields, and coal basins) with respect to their potential to store CO_2.
- Developing a centralized Geographic Information System (GIS) database to display and manipulate stationary source and potential geologic reservoir data. GIS source data were attributed with CO_2 emissions (among other information).
- Estimating capture costs for the sources in the region and conducting a source-sink matching and costing analysis.
- Developing a life cycle analysis model that estimates how non-CO_2 and CO_2 emissions change with the addition of CO_2 capture technology to power plants.
- Developing a web-based, state-by-state compilation of current regulations for injection wells.
- Developing a framework for screening and ranking candidate sites for geologic CO_2 storage on the basis of health, safety, and environmental risks.
- Conducting modeling studies to assess the application of a number of different geophysical techniques for monitoring geologic sequestration.
- Conducting public outreach that resulted in heightened awareness of sequestration among state, community, and industry leaders in the region.

PIER Program Objectives and Anticipated Benefits for California

This work supports California's goal to support the most cost-effective and environmentally sound strategies, including consideration of global climate change, as recommended in the Integrated Energy Policy Report (IEPR) 2005, by

- Taking a leadership role in developing technologies that capture and store CO_2.
- Continuing research performed by the California Climate Change Center in evaluating the economic and ecological consequences of climate change and adaptation and mitigation strategies to preserve and improve quality of life.
- Implementing all strategies identified by the Climate Action Team as needed to meet the governor's greenhouse gas emission reduction goals, including recommendations developed as part of the 2005 IEPR.
- Participating in public outreach efforts to educate the public and businesses in California on climate change impacts and actions to mitigate emissions and encourage stakeholder participation in the development of programs to meet California's climate change goals.

Results

Phase I characterization of major point sources of CO_2 in the region revealed 77 major sources with annual CO_2 emissions of 159 megatonnes (Mt; million metric tons).

Phase I characterization of regional geological reservoirs shows that geologic storage opportunities exist in the WESTCARB region in each of the major technology areas: saline formations, oil and gas reservoirs, and coal basins. California offers outstanding sequestration opportunities because of its large capacity and the potential of value-added benefits from enhanced oil recovery (EOR) and enhanced gas recovery. The estimate for storage capacity of saline formations in the ten largest basins in California ranges from ~150 to ~500 gigatonnes (Gt; billion metric tons) of CO_2, the potential CO_2-EOR storage was estimated to be 3.4 Gt, and the cumulative production from gas reservoirs suggests a CO_2 storage capacity of 1.7 Gt. Matching CO_2 large point sources to geologic storage reservoirs showed that 20, 40, or 80 Mt of CO_2 per year could be sequestered in California at a cost of $31/tonne (t), $35/t, or $50/t, respectively.

In Oregon and Washington, sedimentary basins along the coast offer sequestration opportunities. Of particular interest is the Puget Trough Basin, which contains up to 1130 meters (m) of unconsolidated sediments overlying up to 3050 m of Tertiary sedimentary rocks. The Puget Trough Basin also contains deep coal formations, which are sequestration targets and may have potential for enhanced coal bed methane recovery. The amount of unminable coal in the Puget Sound basin was estimated to be over 70 billion tons, with a CO_2 storage potential of 2.8 Gt.

Using source and sink characterization data as inputs, preliminary source-sink matching was carried out to assess regional geologic sequestration opportunities. The straight-line distance based source-sink matching results showed that if all sinks, including Nevada sinks, were considered for sequestration, more than four-fifths of CO_2 sources could be matched with appropriate sinks within 50 kilometers. A more advanced GIS-based least-cost source-sink matching method was applied to analyze sources and sinks in California, which also takes into account the CO_2 storage capacity constraint of the sinks. For most CO_2 sources in California, the transportation costs to the corresponding EOR site are below $10/t CO_2—less than the assumed $16/t CO_2 credit for EOR injection. A full sequestration costing analysis, which includes capture cost, transportation cost, and injection cost (or net of EOR credit if matched to an EOR site), was also conducted for CO_2 storage in California. The results of this preliminary full sequestration cost analysis indicates that 20, 40, or 80 megatonnes (Mt) of CO_2 per year could be sequestered in California at a cost of $31/tonne (t), $35/t, or $50/t, respectively.

A spreadsheet for carrying out life cycle assessments for power generation including capture was developed. Major point-source pollutants, including CO_2, were addressed. Results of one example analysis, in which all plants in the region are retrofitted with CO_2 controls and replacement power is split 50/50 between gas turbine combined cycle and coal, shows that the CO_2 and SO_2 emissions are reduced, but the NO_x and mercury are increased.

A web-based, state-by-state compilation of current regulations for injection wells—relevant to geologic sequestration—was developed. Links to the specific, relevant statutes are provided. An assessment of the current status of regulations showed that the regulatory framework for CO_2 injection in conjunction with EOR is well established, but the framework for injection into saline formations is poorly defined.

A framework for screening and ranking candidate sites for geologic CO_2 storage on the basis of health, safety, and environmental (HSE) risk was developed based on three fundamental characteristics of a CO_2 sequestration site. Example applications of the framework show that

comparative evaluations of prospective sites with limited characterization data can be accomplished based on potential for CO_2 leakage and seepage and related HSE risk.

As a basis for development of monitoring protocols, modeling studies were carried out to assess the application of a number of different geophysical techniques for monitoring geologic sequestration of CO_2. Time-lapse performance of seismic, gravity, and electromagnetic techniques were considered for a proposed CO_2 sequestration project in the Schrader Bluff field on the North Slope of Alaska. Model results show that both seismic amplitude and seismic amplitude variation with offset could be used to make quantitative estimates of saturation changes, subject to modeling assumptions. Borehole gravity measurements just above the reservoir produced measurable change in the vertical component of gravity that could be used to map lateral distributions of injected CO_2. A preliminary model study for the Rio Vista gas field in California showed that neither gravity nor seismic methods would provide information necessary for monitoring of CO_2 movement because of small changes in reservoir properties.

WESTCARB findings are reported via widely used geographic information system data formats (www.westcarb.org/carbonatlas.htm). The U. S. Department of Energy has combined WESTCARB results with those from other regional partnerships to create NatCarb, a national carbon atlas (www.natcarb.org/ims.html). WESTCARB research results have also been published in DOE's *Carbon Sequestration Atlas of the United States and Canada*, available online at http://www.netl.doe.gov/publications/carbon_seq/refshelf.html.

For more information on WESTCARB projects, visit www.westcarb.org.

Final Report

PIER-EA staff intend to post the final reports on the Energy Commission website in summer 2007 and will list the website link here.

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